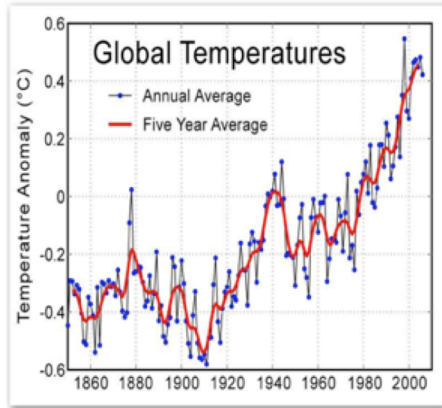


# The role of taxonomic, functional, genetic, and landscape diversity in food-web responses to a changing environment

NSF/NASA Dimensions of Biodiversity

Tony Ives, UW-Madison

# Aphid population dynamics, evolution, and environmental changes at large spatial scales



parasitic wasp attacking  
an aphid



# **Aphid population dynamics, evolution, and environmental changes at large spatial scales**

Jason P. Harmon, North Dakota State University

Kerry M. Oliver, University of Georgia

Volker C. Radeloff, UW-Madison



# **Remote sensing and muddy boots**

1. When and where are the results of micro-scale experiments relevant?
2. When are spatial covariances in remotely sensed variables relevant?
3. How will faster and finer remote sensing change what ecologists can do?

# Messages

Combine remote sensing with experiments.

NEON is nice, but there is a lot more out there (muddy boots).

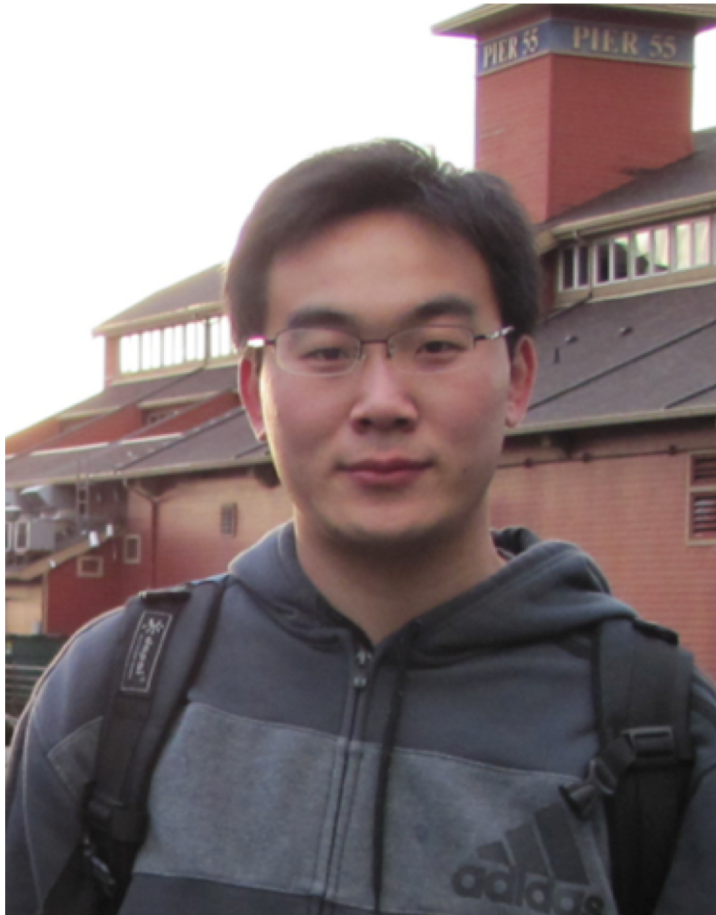
Incremental changes in technology can lead to step changes in applications.

Improving current products is not just more of the same.

# **Remote sensing and muddy boots**

1. When and where are the results of micro-scale experiments relevant?
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# 1. When and where are the results of micro-scale experiments relevant?

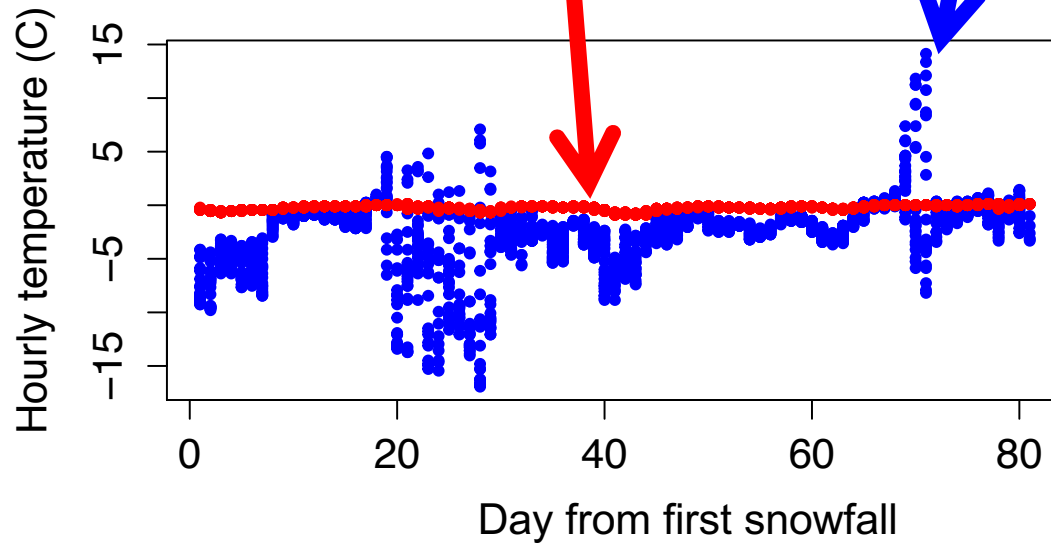


Likai Zhu



Brandon Barton

# Snow is an insulator

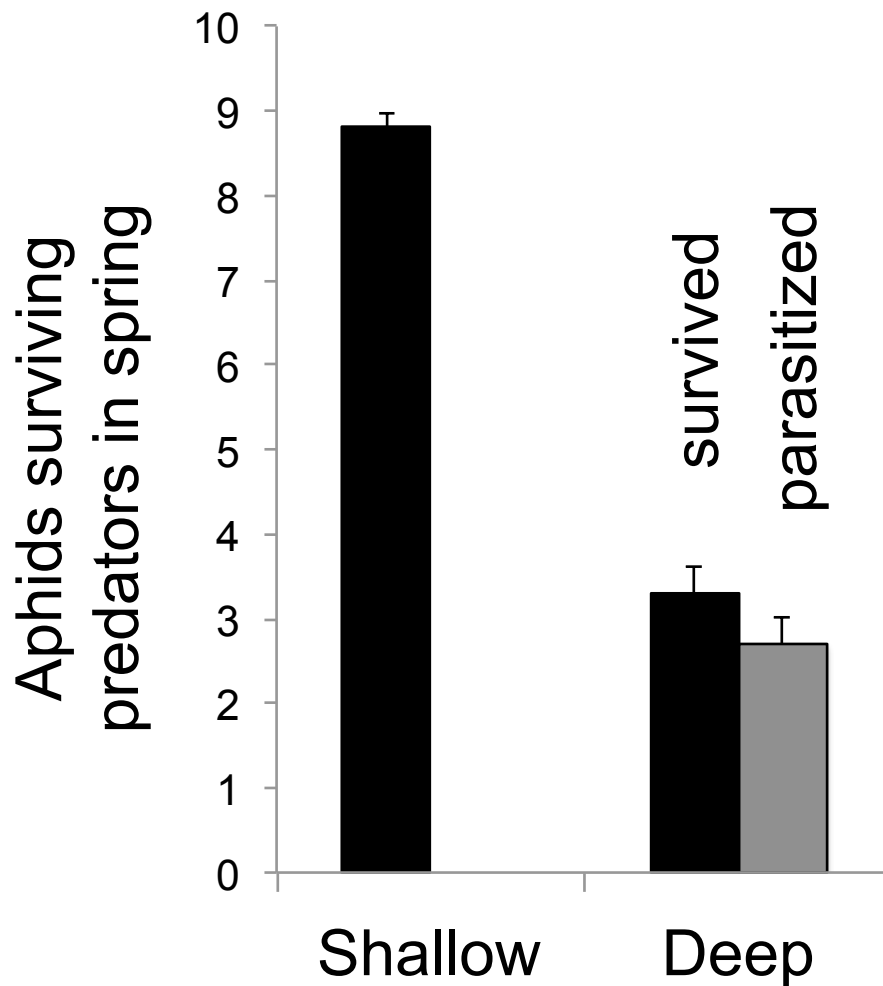
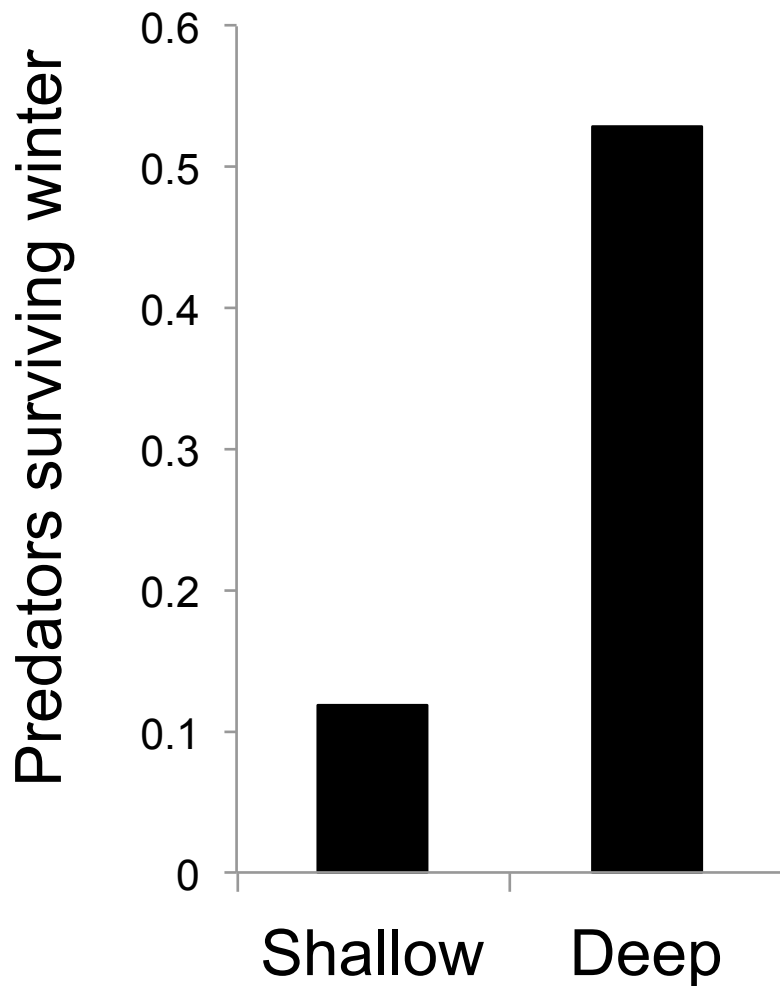




What is the effect on aphids the following spring?

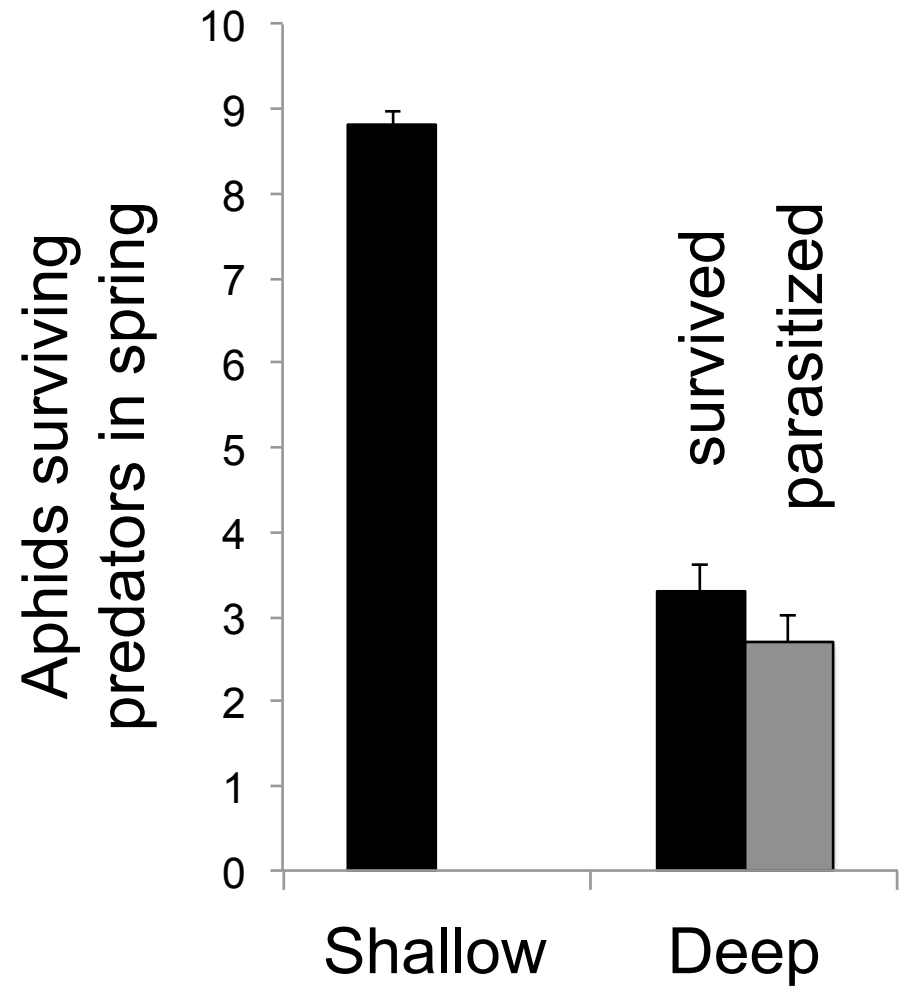
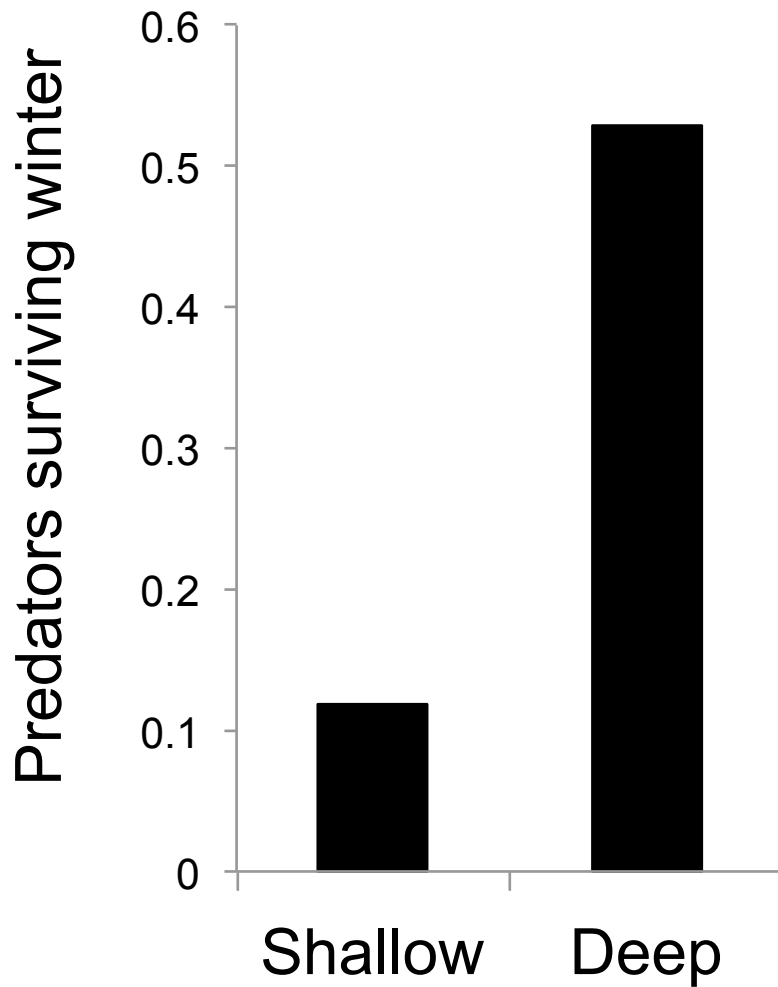


# Less snow reduces predation and increases aphid density





# Snow matters: less snow could increase pest abundances



1. When and where are the results of micro-scale experiments relevant?

Experiment done during 1 winter in 48 m<sup>2</sup>

Has snow cover changed through the years?

If so, at what spatial scale?

1. When and where are the results of micro-scale experiments relevant?

Experiment done during 1 winter in 48 m<sup>2</sup>

Has snow cover changed through the years?

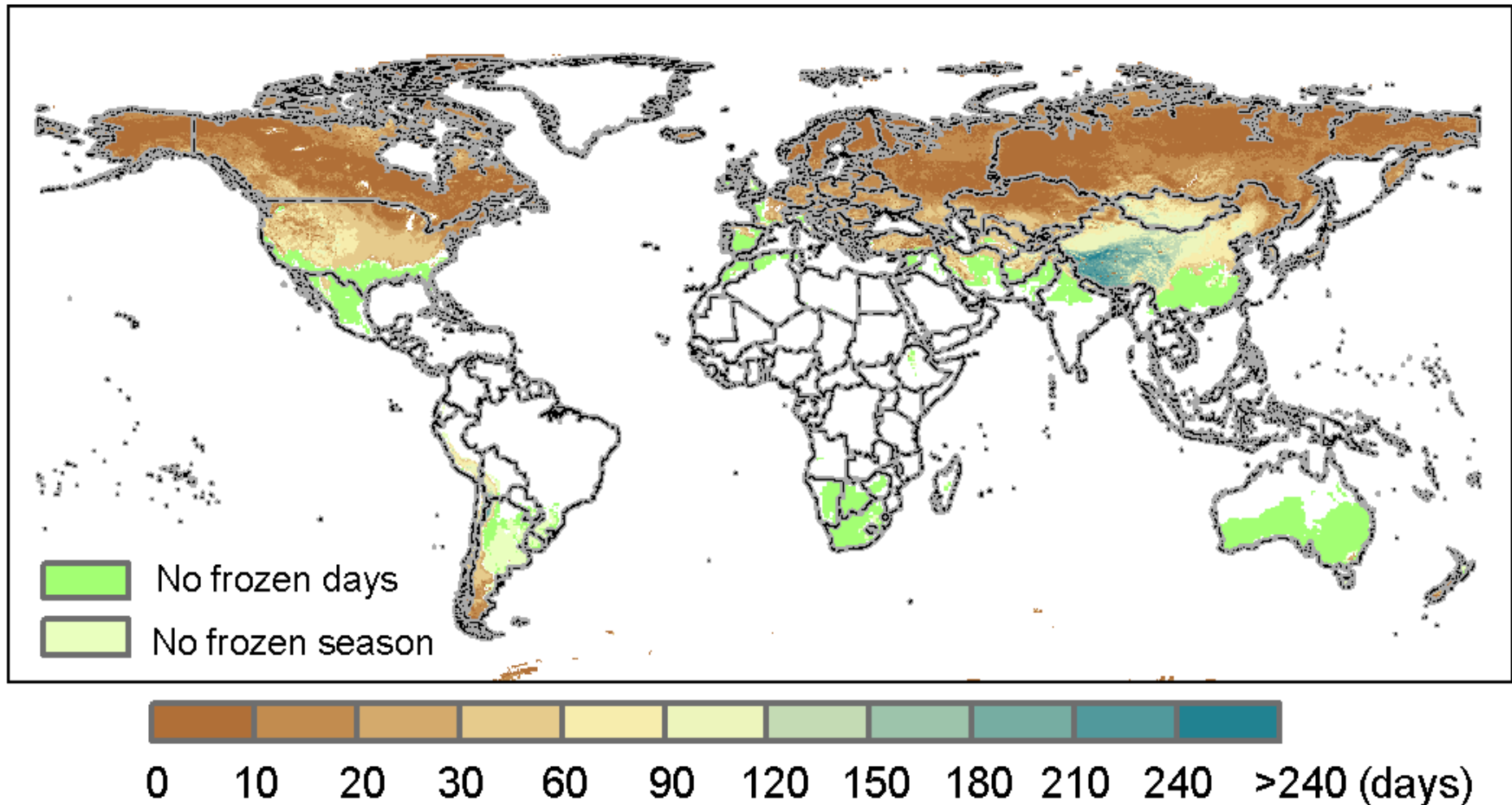
If so, at what spatial scale?

Remote sensing contains a lot of historical evidence.

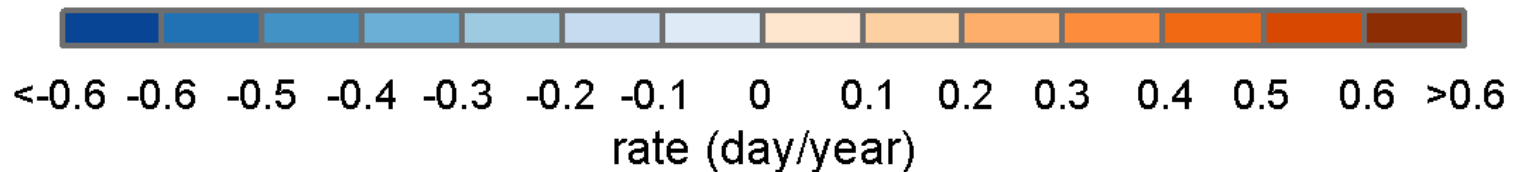
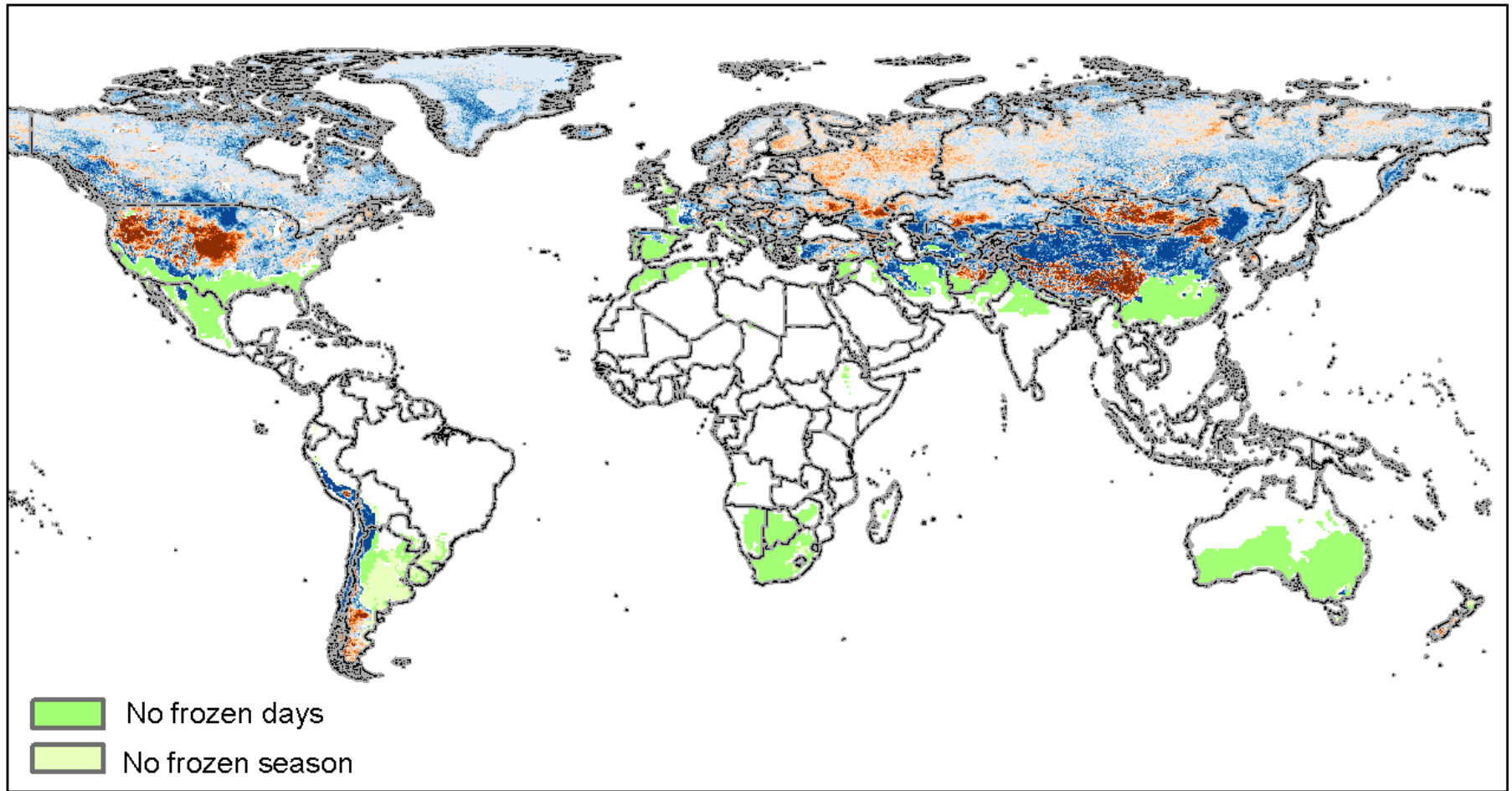
# Frozen days without snow are common at mid latitudes

MODIS Snow Cover

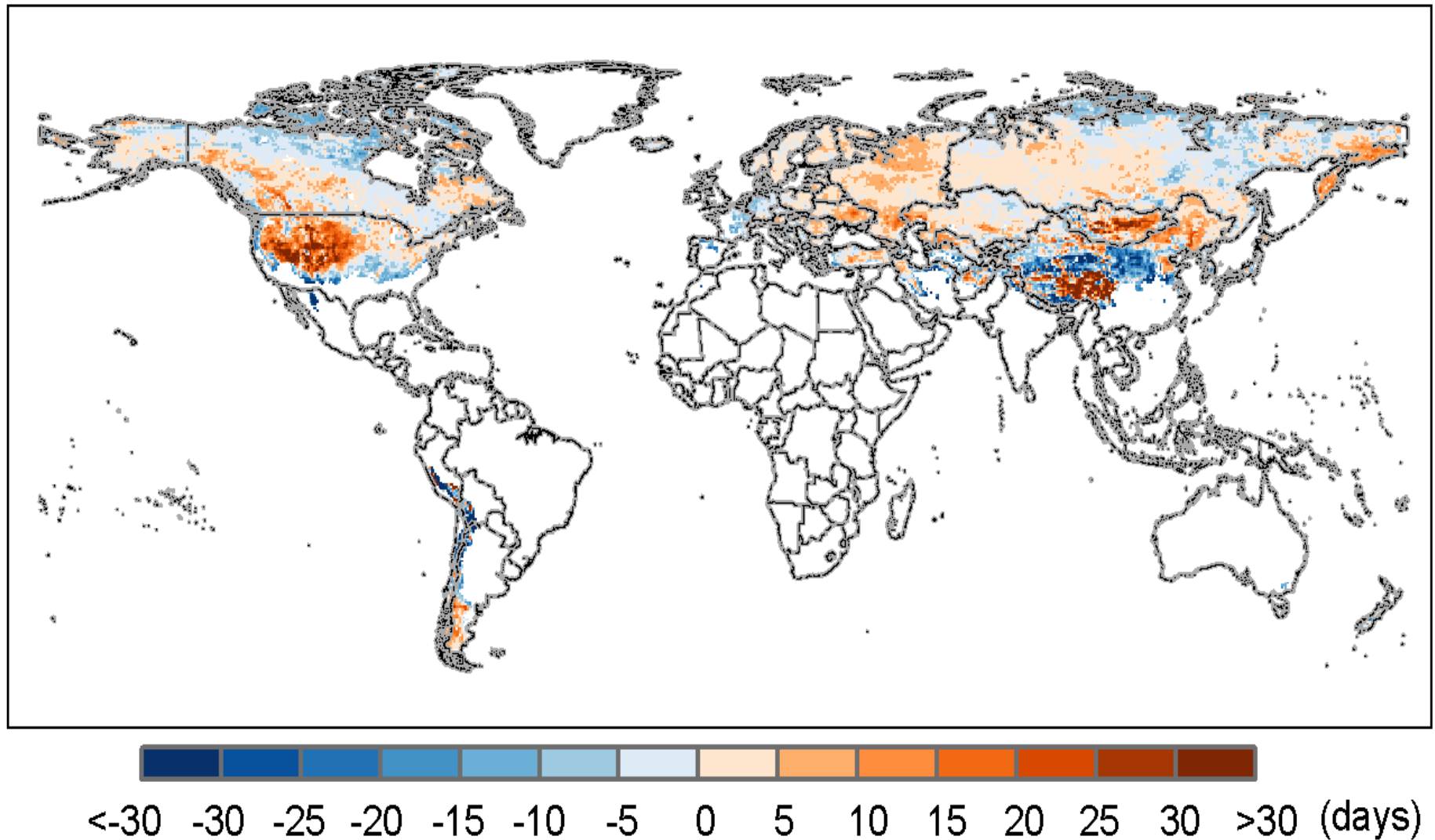
Landscape Freeze/Thaw Status: SMMR, SSM/I, and SSMIS



# Rate of change in the number of days with frozen ground but no snow, 1982-2014



# Predicted change from the RCP8.5 high emission scenario, 2041-2070





Global warming over decades will make large areas of the world functionally colder in winter

This magnifies the consequences of the experiment.



Snow is important for many plants and animals.

## Subnivium

This magnifies the relevance of remote sensing.





# Interfacing remote sensing with experiments

For ecology: Provides broader context for the experiment.

For remote sensing: Provides motivation for integrating different products in biologically informative ways.

# **Remote sensing and muddy boots**

1. When and where are the results of micro-scale experiments relevant?
2. When are spatial covariances in remotely sensed variables relevant?
3. How will faster and finer remote sensing change what ecologists can do?

## 2. When are spatial covariances in remotely sensed variables relevant?

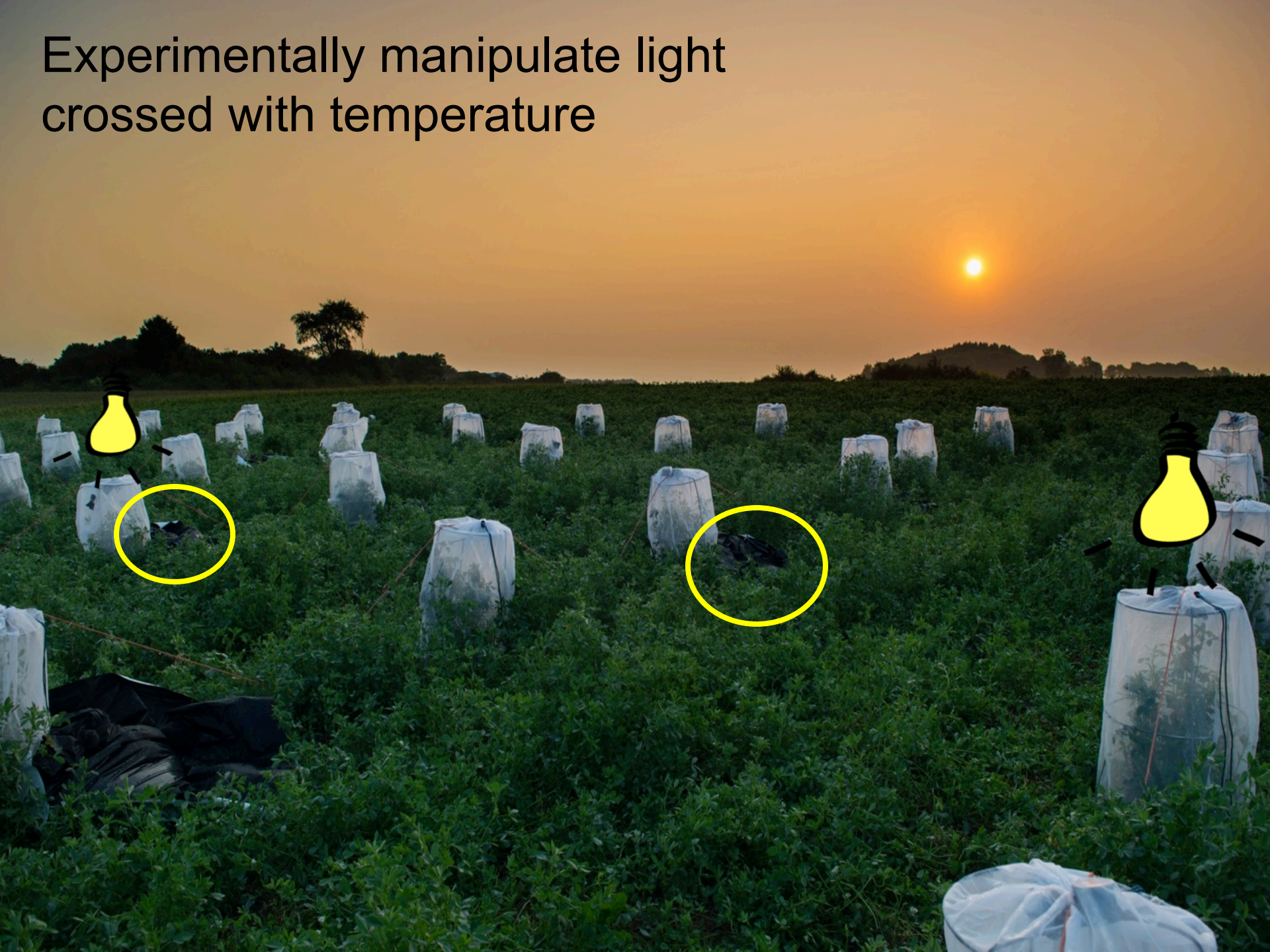
Interactive effect of light pollution and nighttime temperature on predation of aphids



Colleen Miller



Experimentally manipulate light  
crossed with temperature





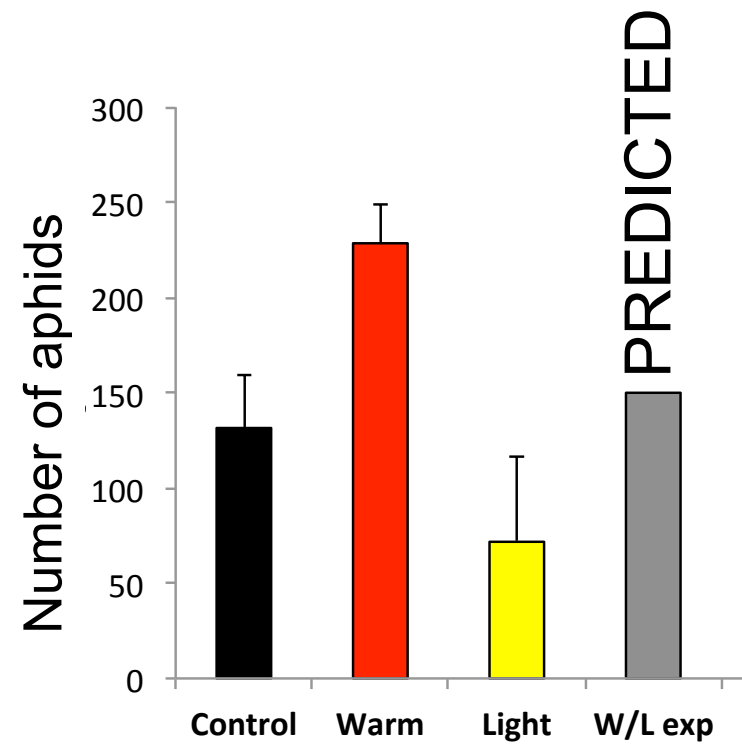
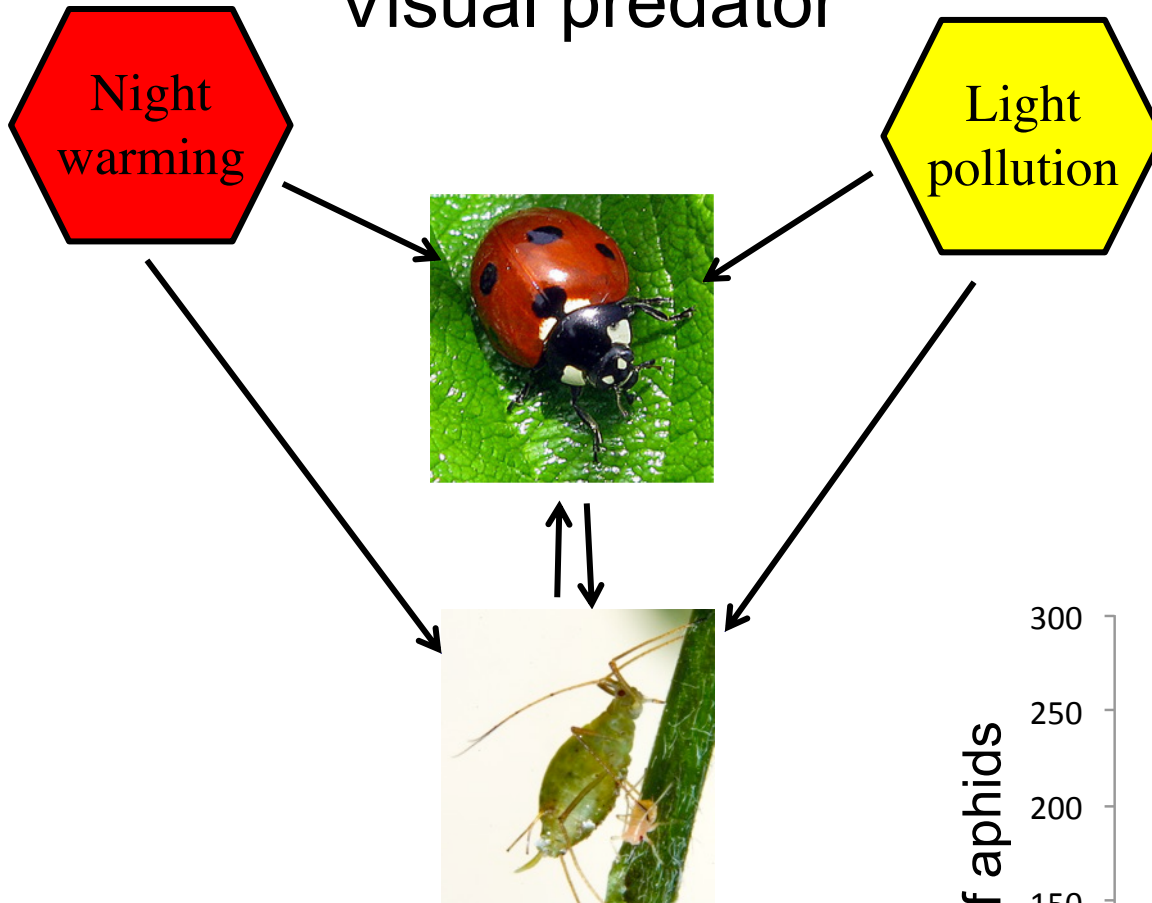
Visual hunter



Hunts in the dark

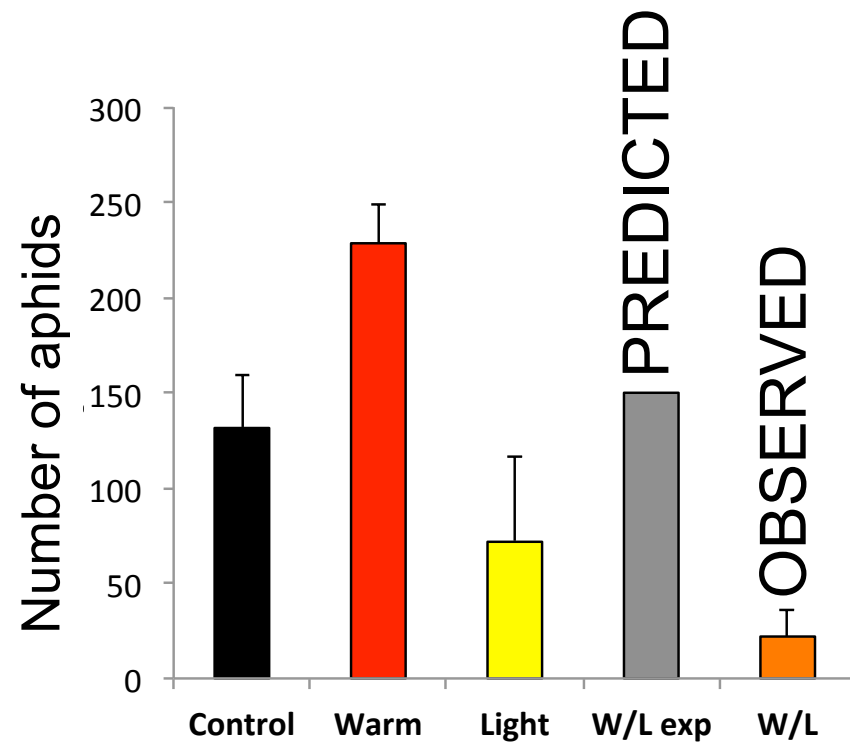
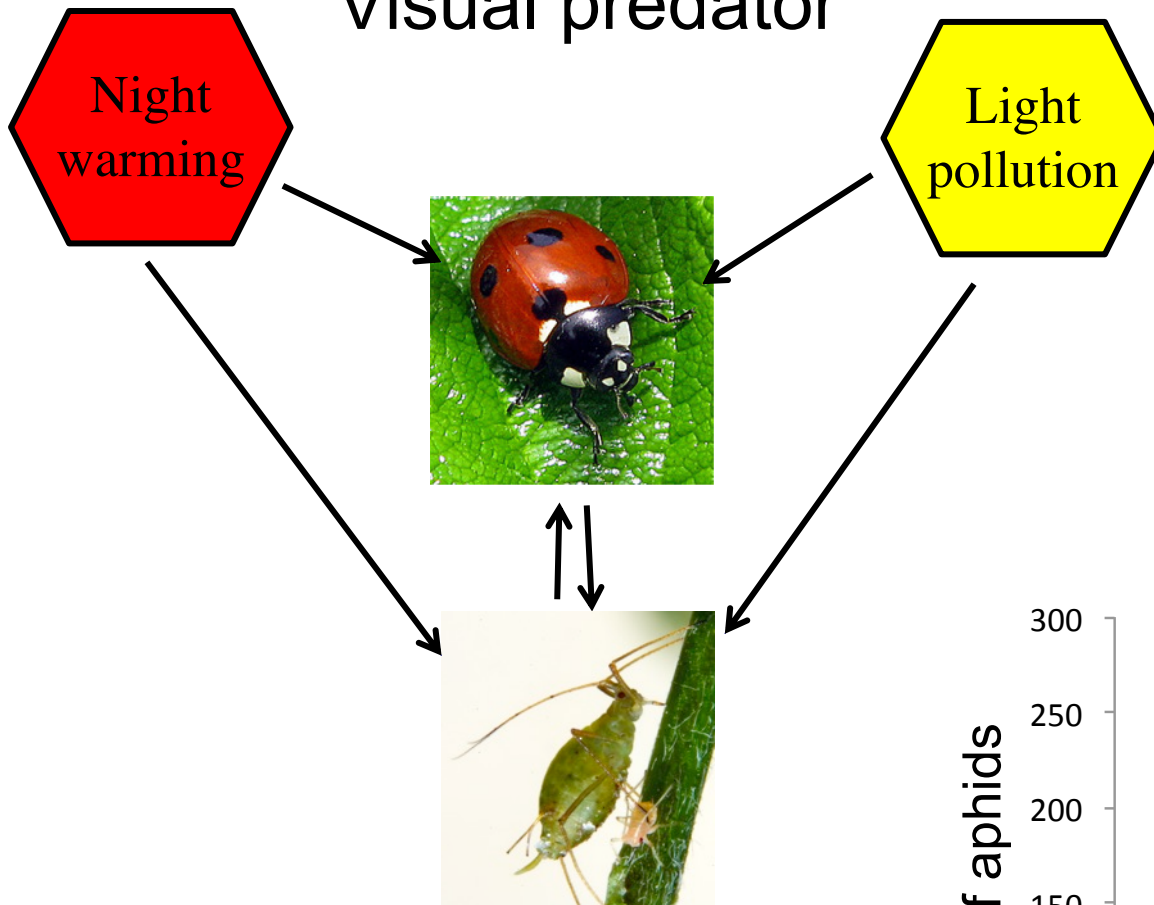


# Visual predator



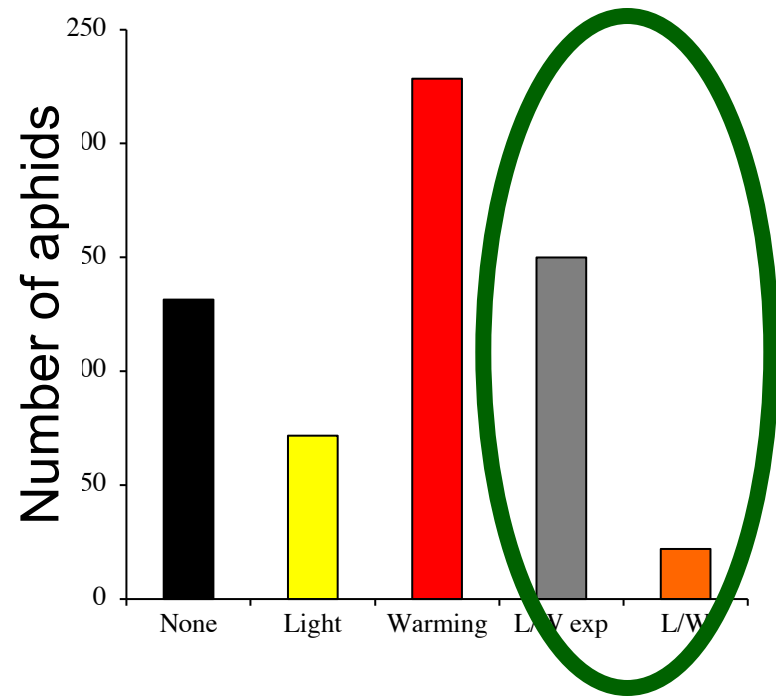


# Visual predator

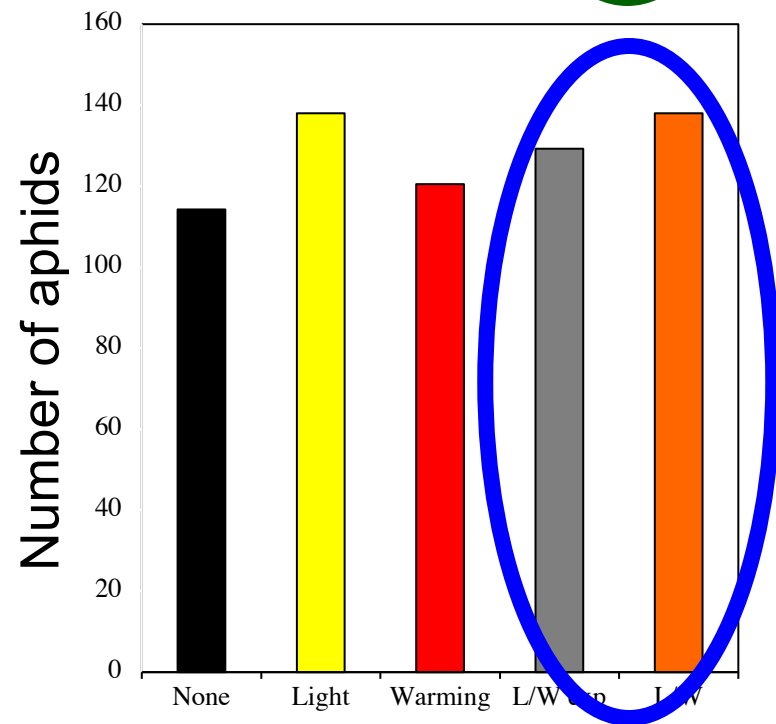




Visual hunter



Hunts in the dark

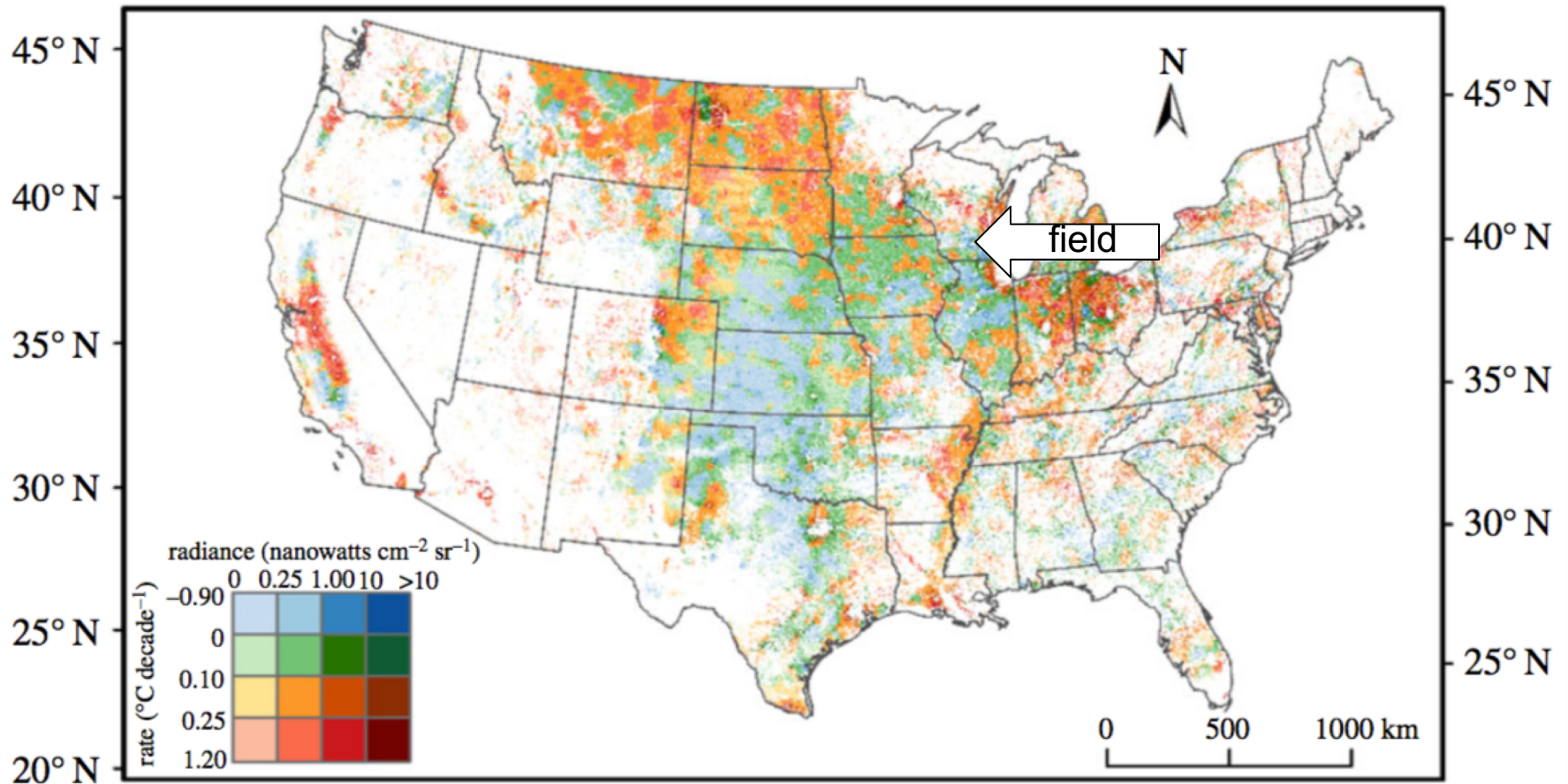




# Interfacing remote sensing with experiments

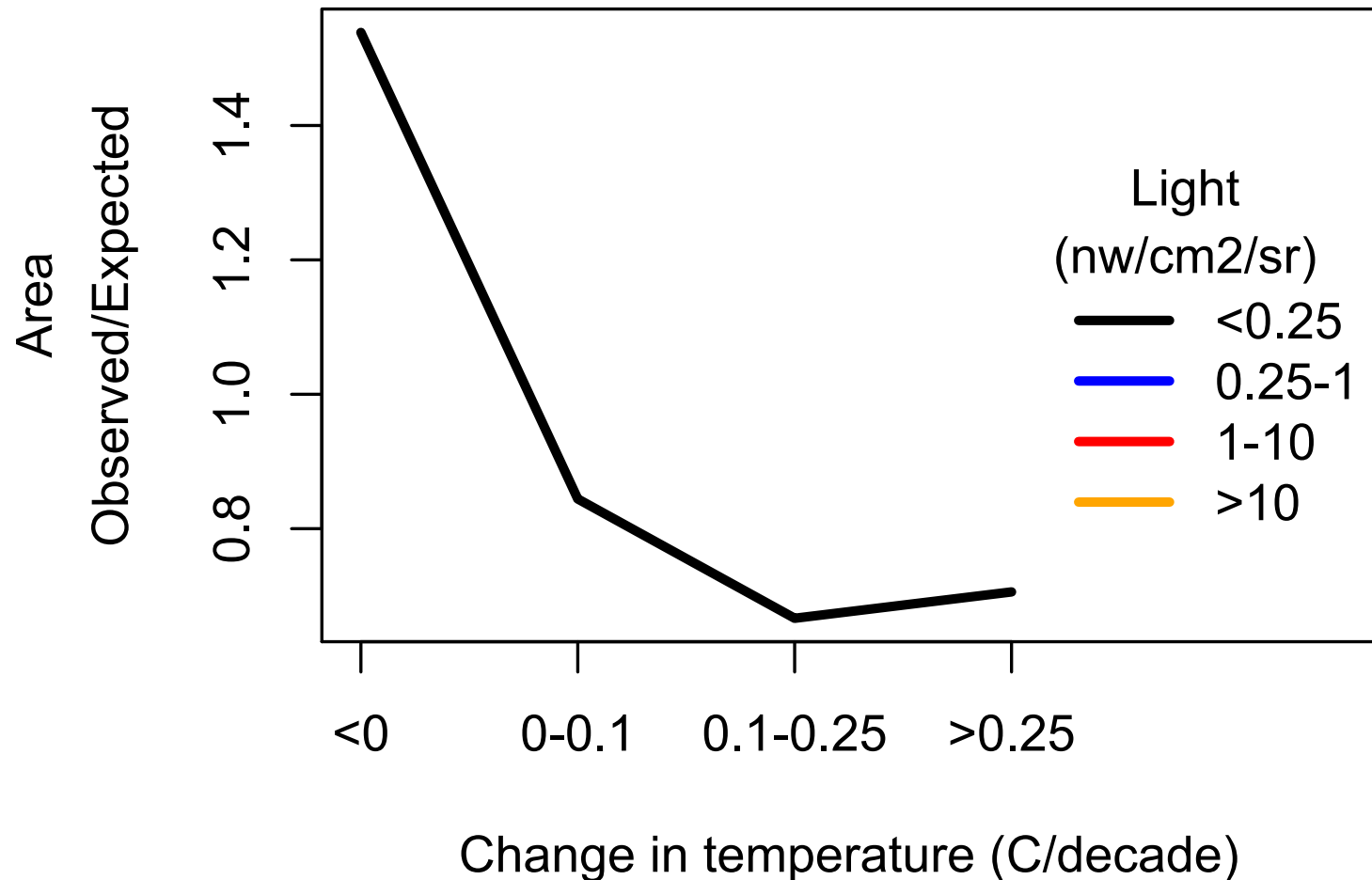
For ecology: Provides broader context for the experiment.

# Co-occurrence of nighttime irradiance and decadal change in temperature

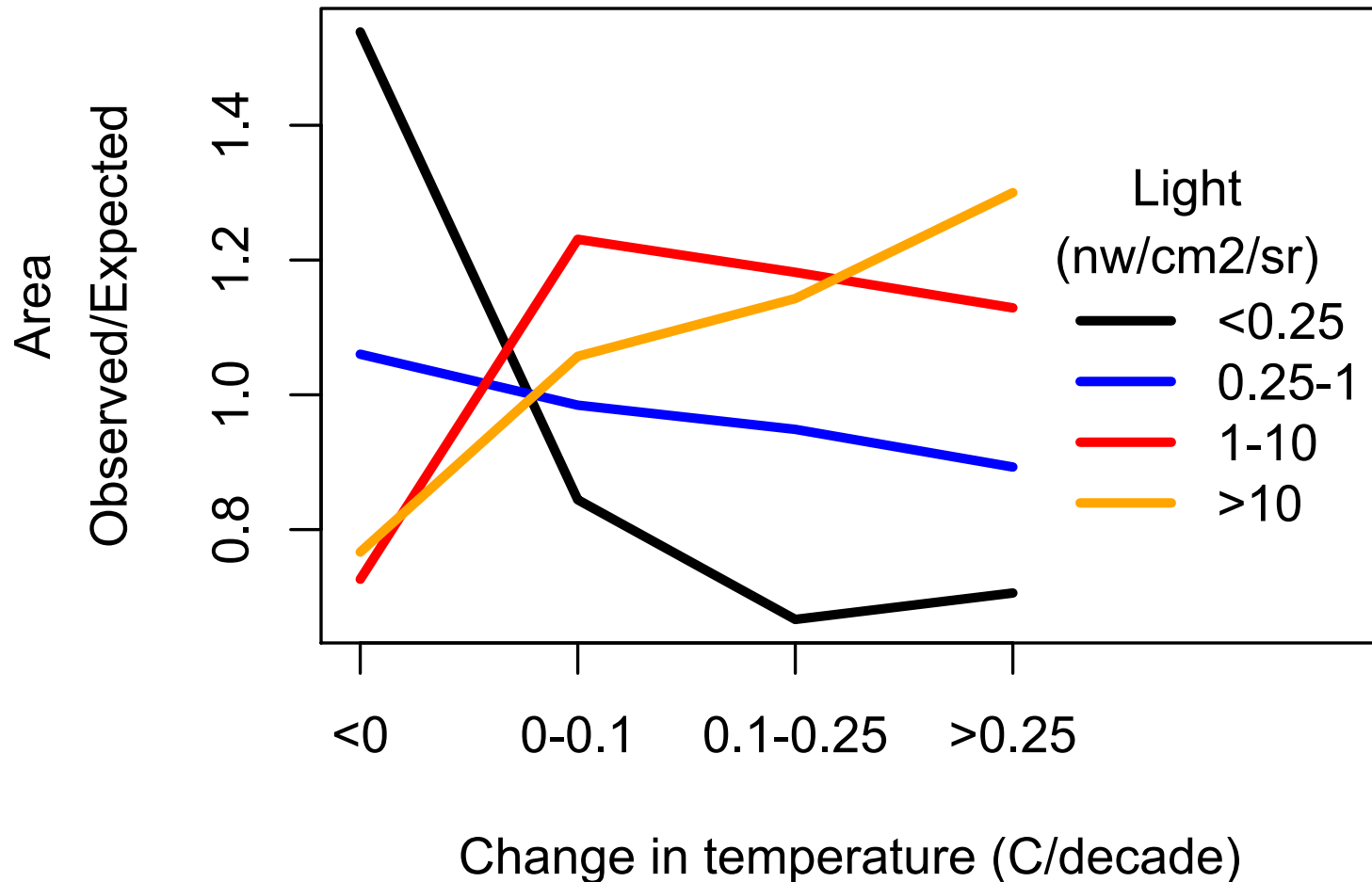


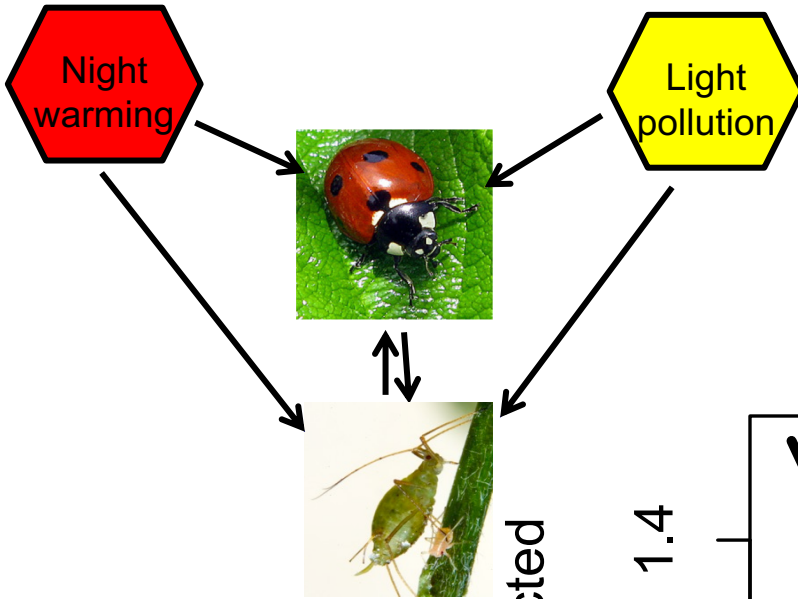
Map for US cropland

# Positive covariance in light pollution and nighttime warming

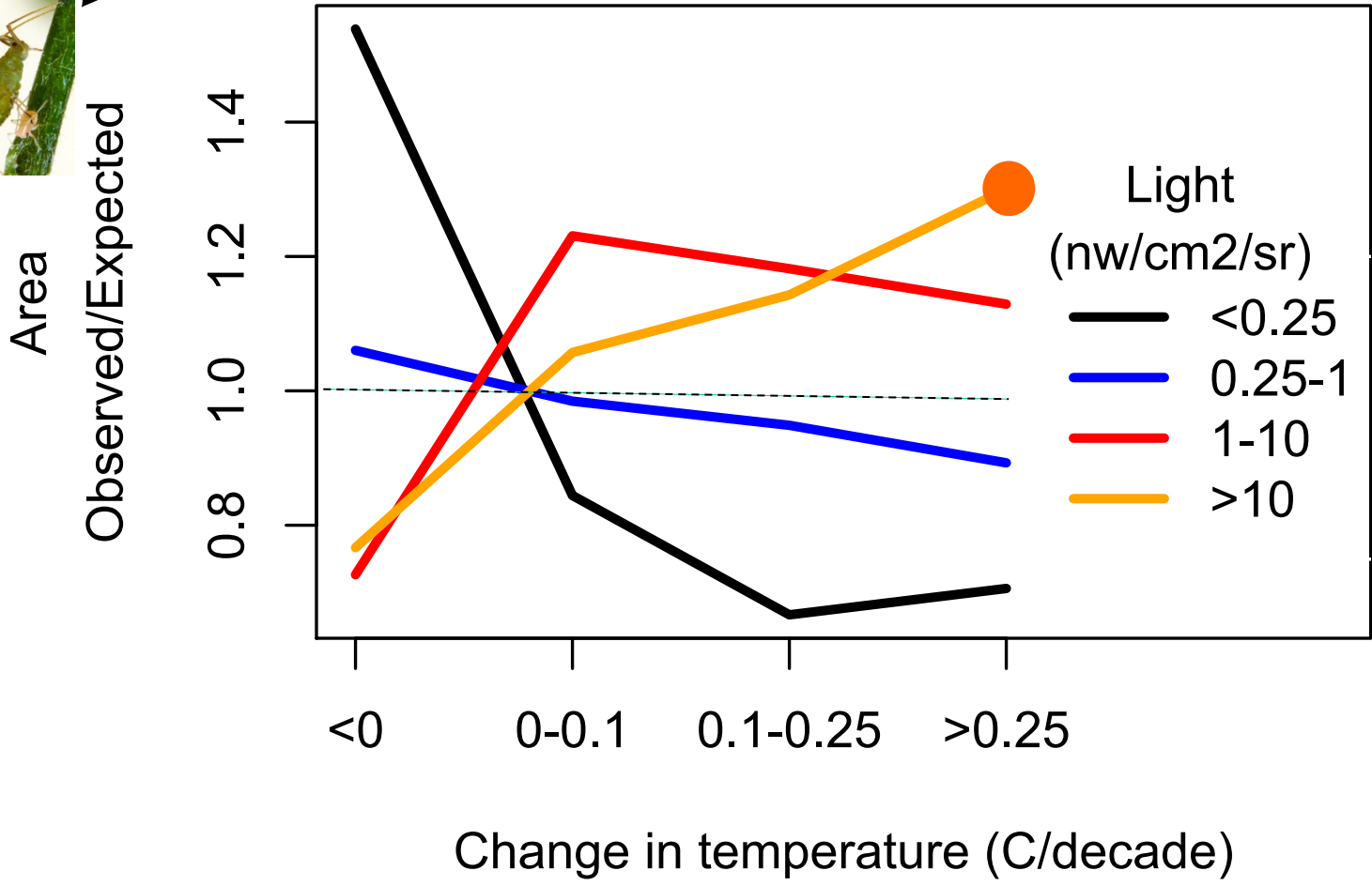


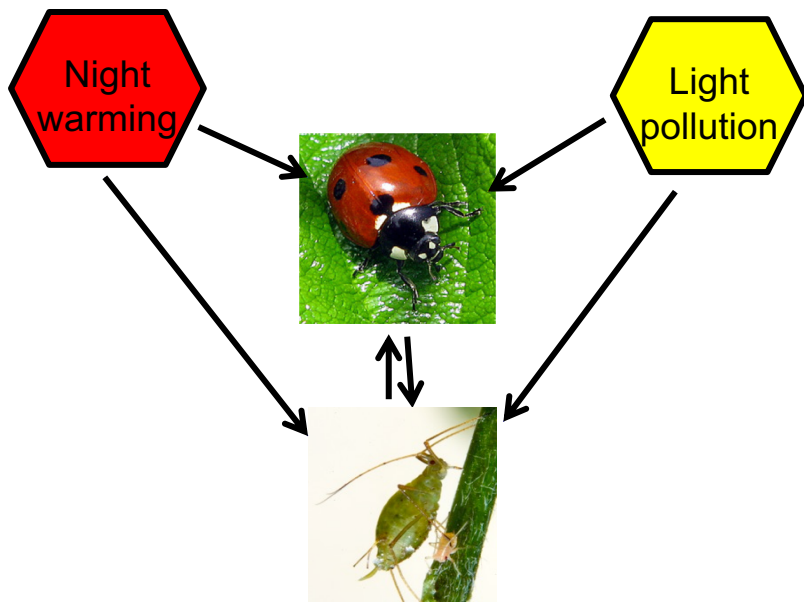
# Positive covariance in light pollution and nighttime warming





30% increase in effect





If there were no interaction between light pollution and increasing temperature in the biological system, spatial covariance would be irrelevant.

# Interfacing remote sensing with experiments

For ecology: Provides broader context for the experiment.

We are not trying to forecast.

Experiments show what is possible, not what is.

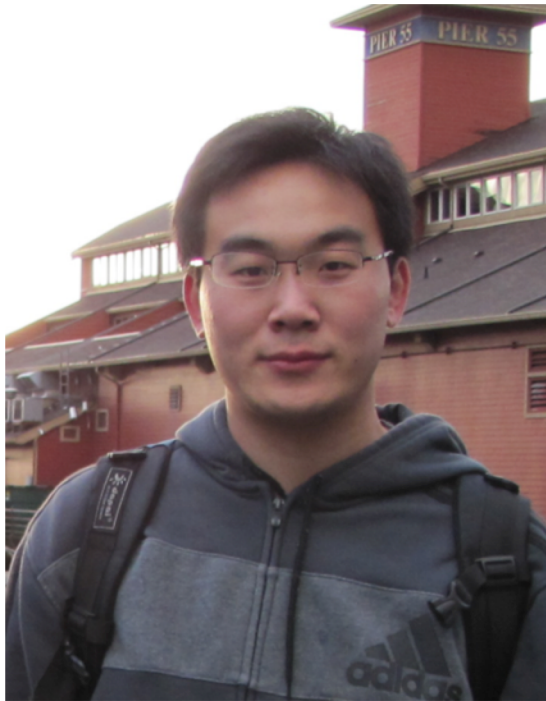
For remote sensing: Provides justification for investigating spatial covariances among variables.

# **Remote sensing and muddy boots**

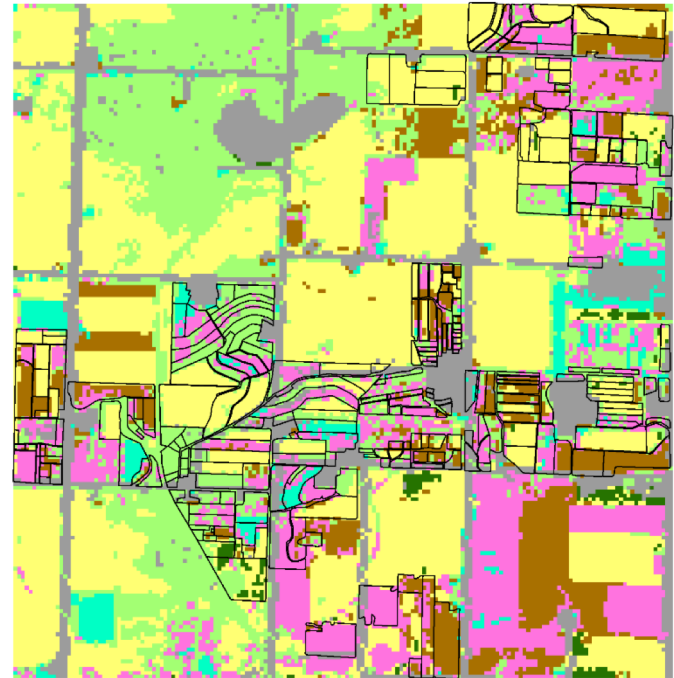
1. When and how are the results of micro-scale experiments relevant?
2. When are spatial covariances in remotely sensed variables relevant?
3. How will faster and finer remote sensing change what ecologists can do?



### 3. How could faster and finer remote sensing change what ecologists can do?

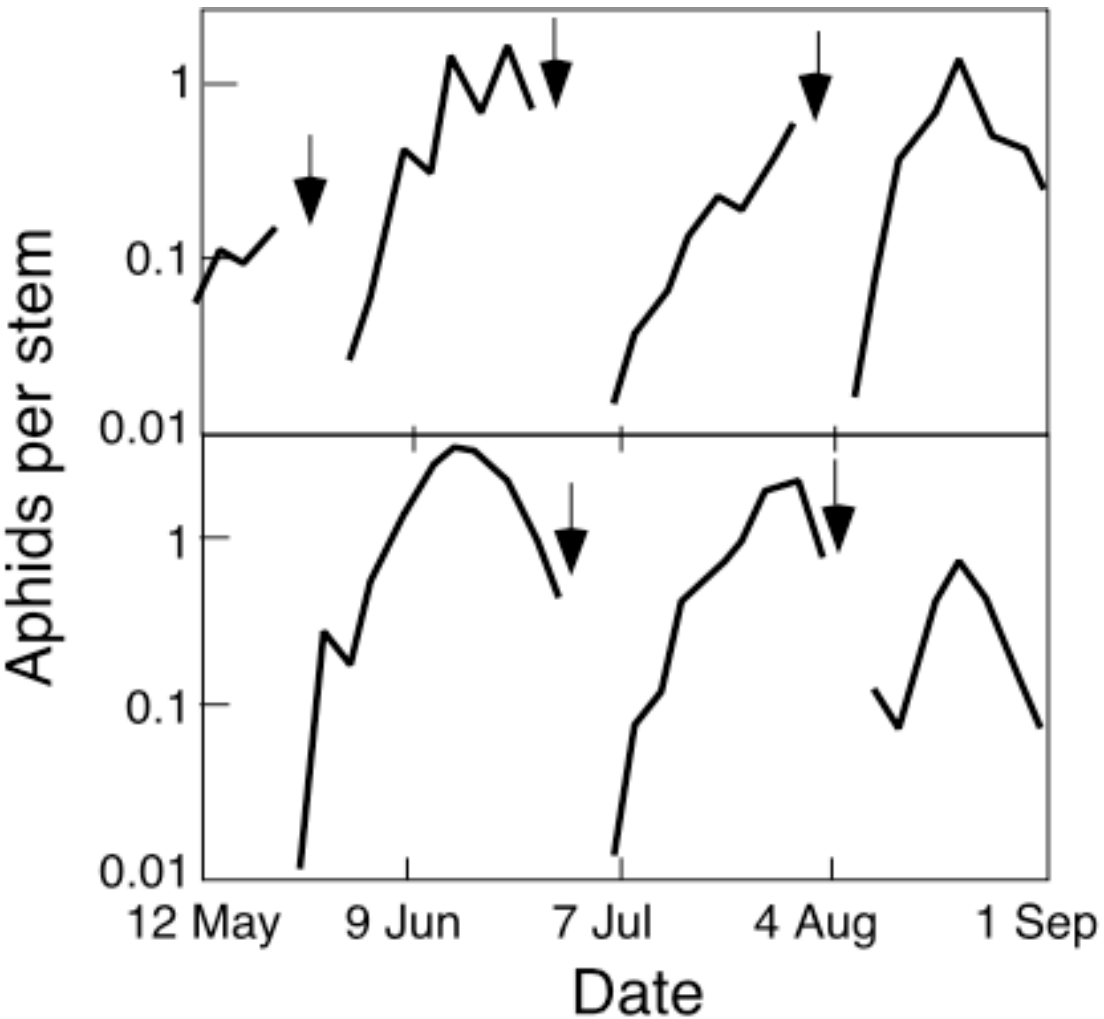


Likai Zhu



Fusion of Landsat + MODIS

# Temporally varying agricultural landscape

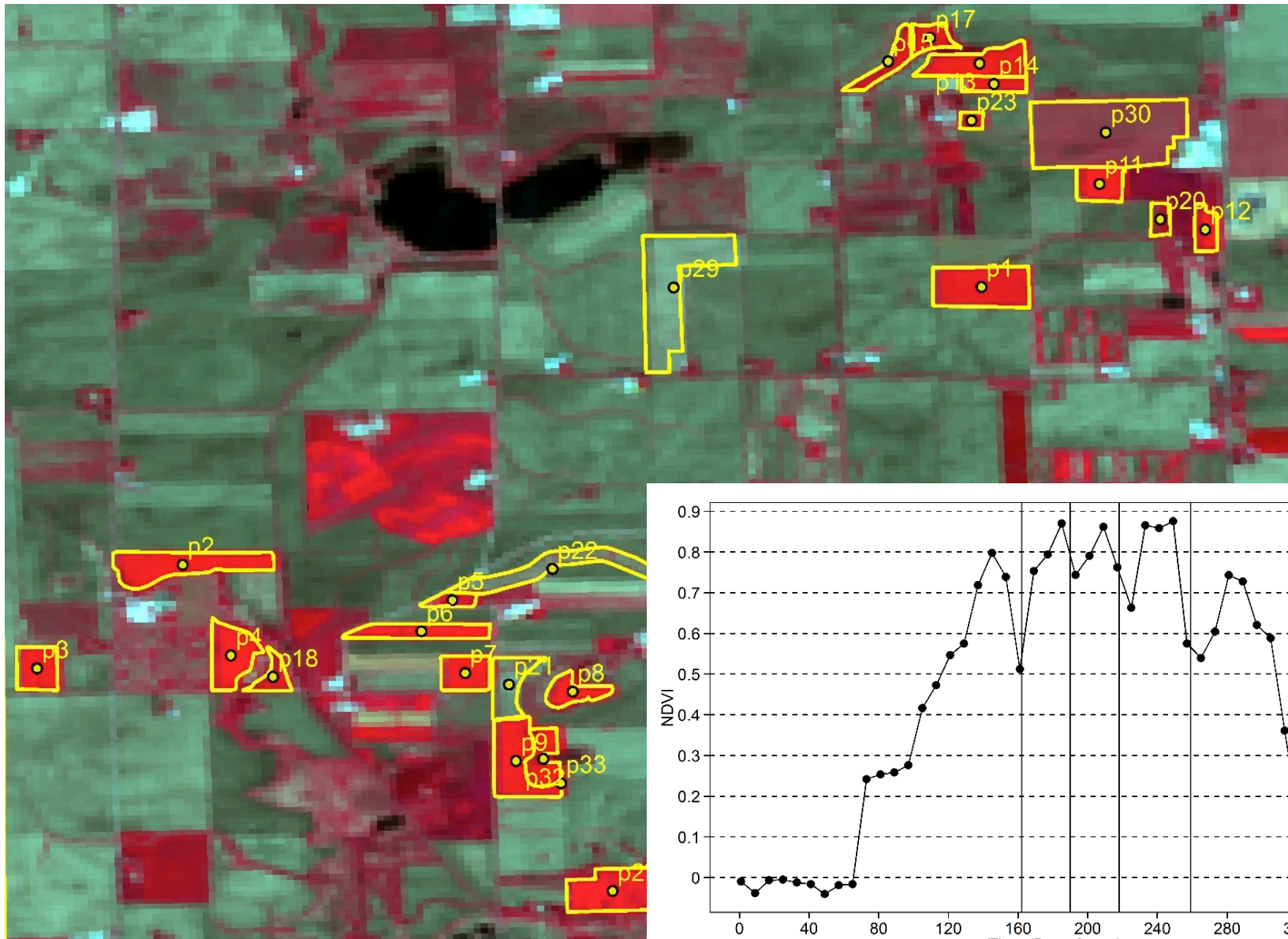


# Trying to reconstruct harvesting patterns by remote sensing

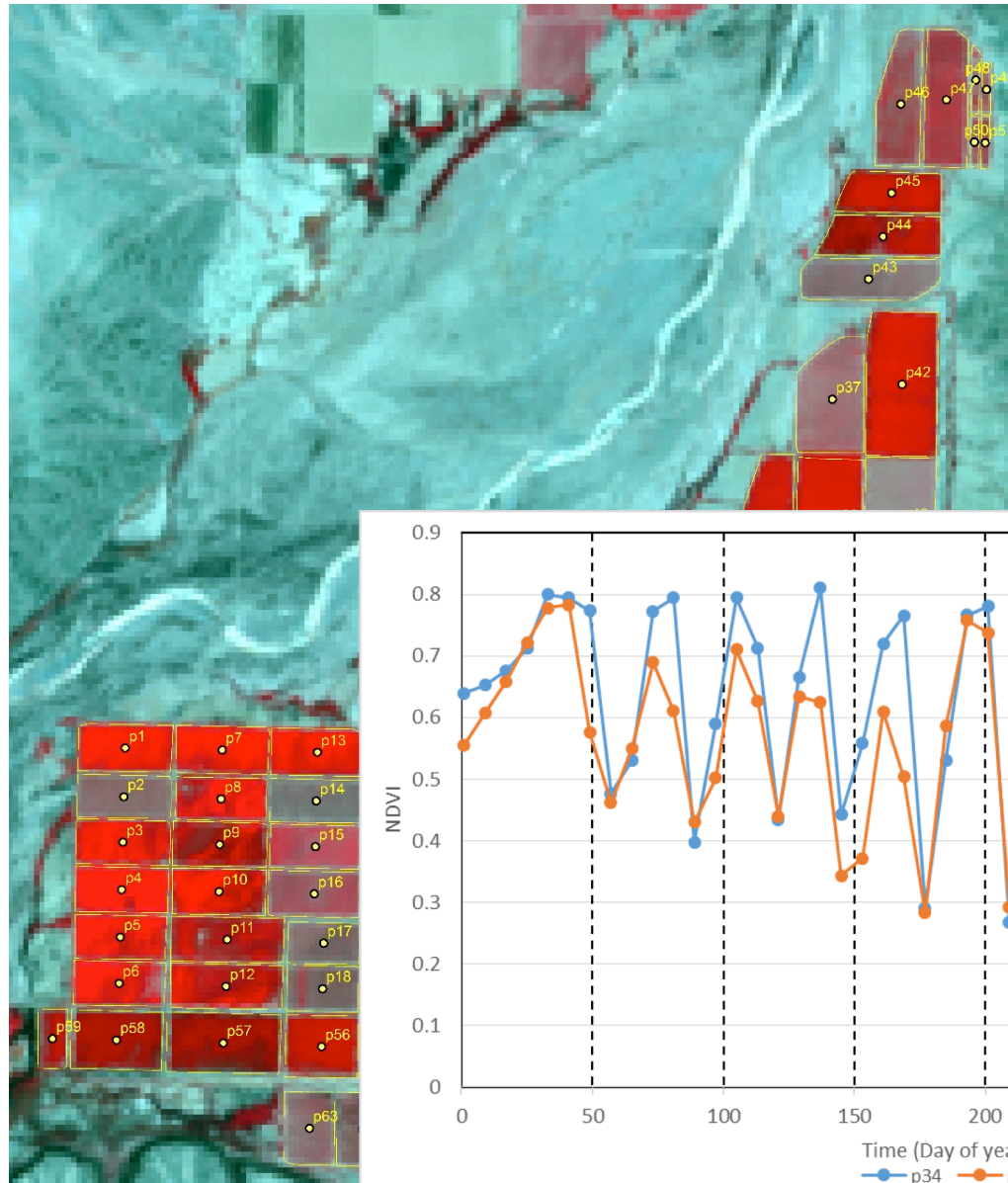




Spatial resolution from MODIS wasn't fine enough when ground truthed.

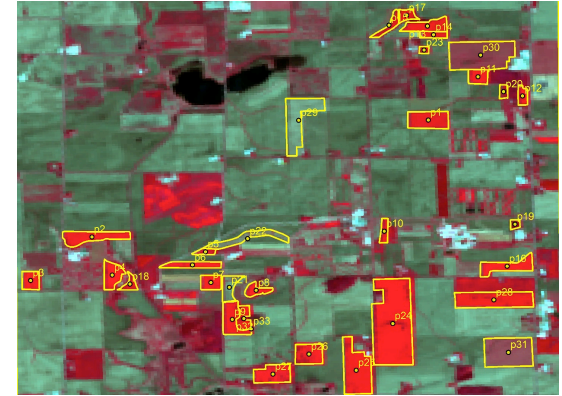


# It worked fine in Arizona



# Projects from my lab that could use Sentinel 2a/2b or Landsat 7/8

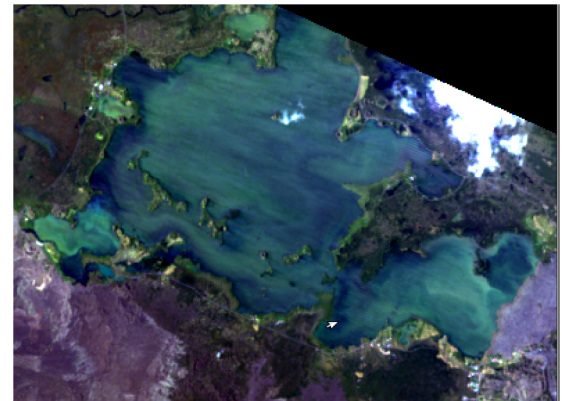
Harvesting mosaic of alfalfa



Alfalfa mosaic virus



Algae blooms in Myvatn

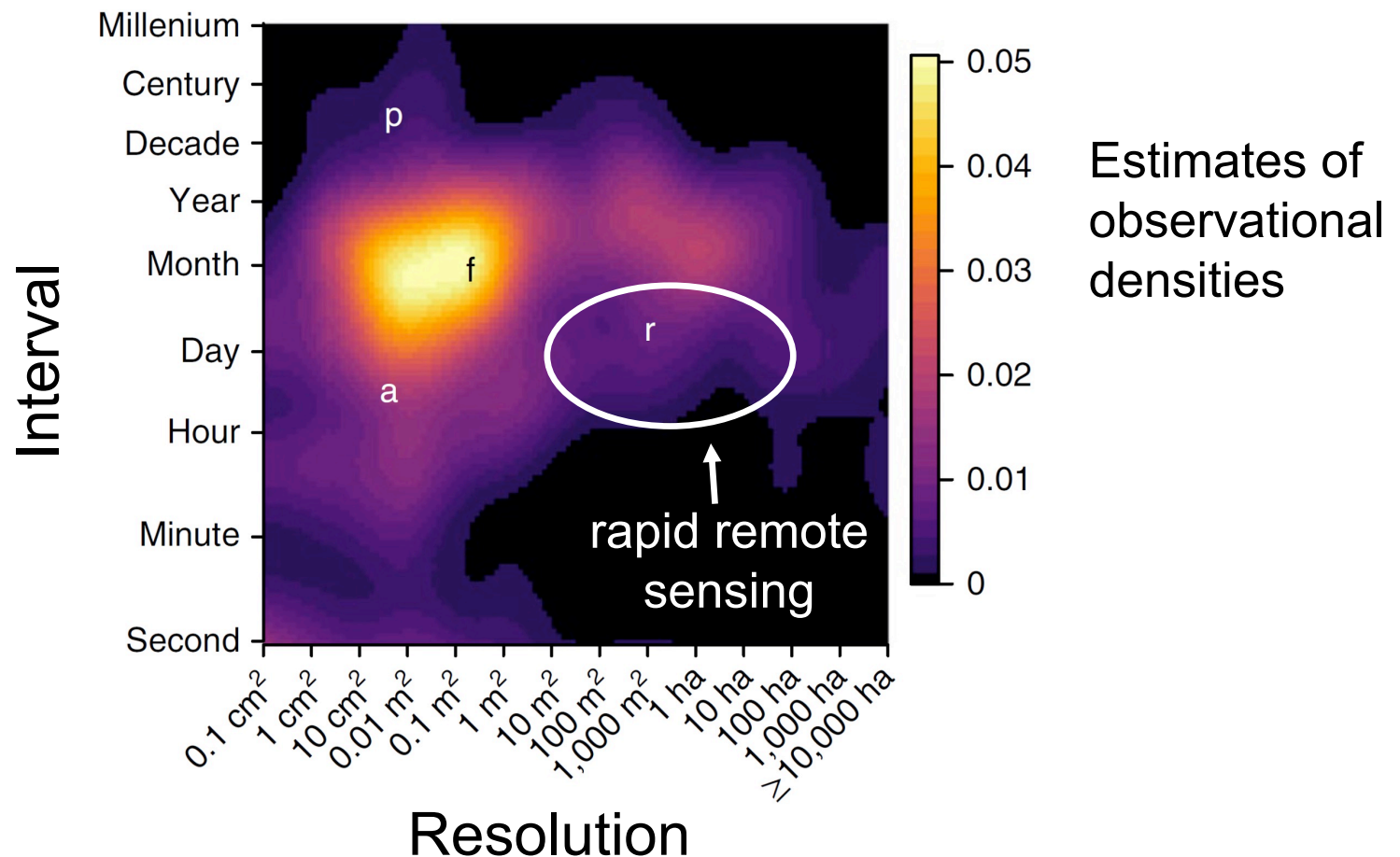


Phil Townsend



# What about other ecological studies?

Review of 348 randomly selected observational studies (Estes et al. 2018, Fig. 2)





Reviewed the 284 articles in the  
journal *Ecology* in 2017

no apparent application for RS

used RS at a single time point

used RS at multiple time points

could use RS at a single time

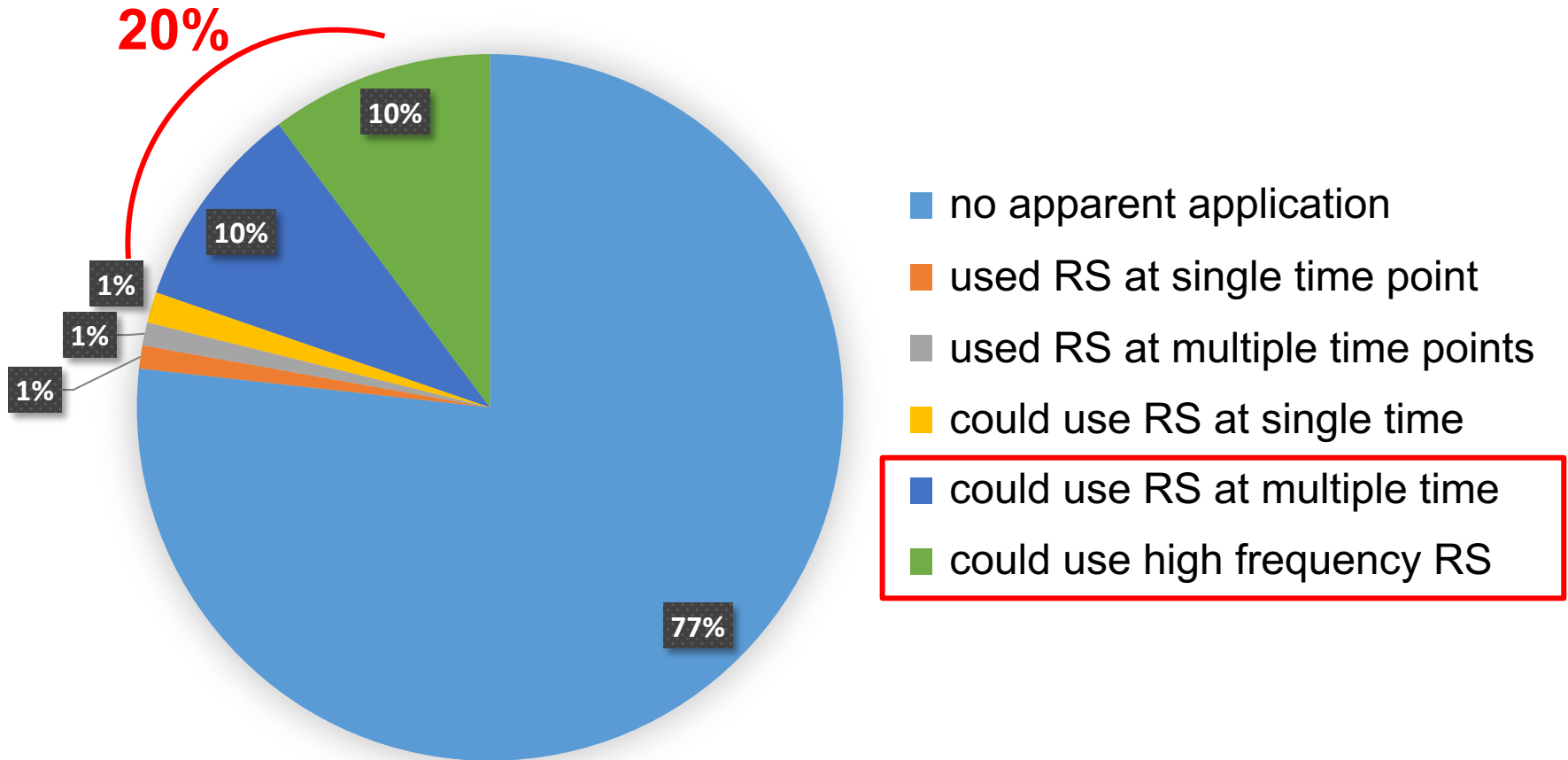
could use RS at multiple times

could use high frequency RS  
( $\leq 7$  day interval)



Rachel Penczykowski

2% used remote sensing, but **20%** could have used temporally replicated remote sensing data



# Ecological uses of multiple, repeated images

	<b>Yearly</b>	<b>Monthly</b>	<b>Weekly</b>	<b>Daily</b>
<b>Disturbance</b>	Logging Fire in forests	Drought Wind damage	Fire in grasslands Insect defoliation Frost damage	Fire spread Heat waves Flooding
<b>Movement</b>	Range expansion	Migration	Human encroachment	Foraging Migration
<b>Ecosystem processes</b>	Trends in GPP	Variance in GPP	Nutrient flushing	Nutrient loading
<b>Population dynamics</b>	Fragmentation	Plague insects	Plant disease Animal survival	Phenologies Algal blooms Insect emergence

Show ecological uses of remote sensing  
Show remote sensing applications in ecology

Incremental changes in technology can lead to step changes in applications.

Improving current products is not just more of the same.

Combine remote sensing with experiments.

The answers to my questions have always seemed to be at the next-larger scale.





# Remote sensing products, past and future

Spatial scale (m)		1980s	1990s	2000s	Currently	Near future
<b>1–5</b>	Frequency			Occasionally	3–5 days	Daily
	Satellites			Commercial	PlanetLabs	PlanetLabs
<b>10</b>	Frequency		Occasionally		Weekly	Weekly
	Satellites		SPOT		Sentinel 2a, 2b	Sentinel 2a, 2b
<b>30</b>	Frequency	Bi-weekly	Bi-weekly	Bi-weekly	3–5 days	3–5 days
	Satellites	Landsat	Landsat	Landsat	Landsat 7, 8; Sentinel 2a, 2b	Landsat 7, 8; Sentinel 2a, 2b
<b>250–1000</b>	Frequency			2x daily	4x daily	
	Satellites			MODIS	MODIS, VIIRS	VIIRS, NPOESS
<b>8000</b>	Frequency					
	Satellites	AVHRR	AVHRR	AVHRR	Geostationary	